

***PIEZOELECTRIC MICRO-TRANSDUCERS, METHODS OF USE  
AND MANUFACTURING METHODS FOR SAME***

***ABSTRACT***

- 5           Various micro-transducers incorporating piezoelectric materials for converting energy  
in one form to useful energy in another form are disclosed. In one embodiment, a piezoelectric  
micro-transducer can be operated either as a micro-heat engine, converting thermal energy into  
electrical energy, or as a micro-heat pump, consuming electrical energy to transfer thermal  
energy from a low-temperature heat source to a high-temperature heat sink. In another  
10   embodiment, a piezoelectric micro-transducer is used to convert the kinetic energy of an  
oscillating or vibrating body on which the micro-transducer is placed into useful electrical  
energy. A piezoelectric micro-transducer also is used to extract work from a pressurized stream  
of fluid. Also disclosed are a micro-internal combustion engine and a micro-heat engine based  
on the Rankine cycle in which a single fluid serves as a working fluid and a fuel.